Exemption No. 7496

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98055-4056

In the matter of the petition of

The Boeing Company

for an exemption from § 25.961(a)(5) of Title 14, Code of Federal Regulations.

Regulatory Docket No. FAA-2000-8062

GRANT OF EXEMPTION

By letter B-H340-00-3689, dated June 28, 2000, Mr. R. C. Shields, Manager, Airplane Certification, Twin Aisle Deliveries and Fleet Support, The Boeing Company, Mail Code 02-79, P.O. Box 3707, Seattle, Washington 98124-2207, petitioned the Federal Aviation Administration, for an exemption from § 25.961(a)(5) of Title 14, Code of Federal Regulations (14 CFR). The requested exemption, if granted, would permit the use of a maximum temperature limitation of 80°F for JP-4 and Jet B fuels on the Boeing Model 747-400/-400F/RB11-524G-T/H-T airplane.

The petitioner requests relief from the following regulation:

Section 25.961 Fuel system hot weather operation

(a) The fuel system must perform satisfactorily in hot weather operation. This must be shown by showing that the fuel system from the tank outlets to each engine is pressurized, under all intended operations, so as to prevent vapor formation, or must be shown by climbing from the altitude of the airport elected by the applicant to the maximum altitude established as an operating limitation under Sec. 25.1527. If a climb test is elected, there may be no evidence of vapor lock or other malfunctioning during the climb test conducted under the following conditions:
. . .
(5) The fuel temperature must be at least 110 deg. F.

The petitioner's supportive information is as follows:

"Introduction

"References: (a) Boeing Document D6-13314, 747-200 Flight Test Certification Report, "Fuel Feed System Flight Demonstration (Suction Feed) Rolls-Royce RB211-524B Engines in 747-200 Airplane RD131"

(b) Boeing Document D6-35671, 747-400 Flight Test Certification Report, Section C2.18.0037, "747/RB211-524 Fuel System Suction Feed Demonstration"

(c) Boeing Document, "Fuel System Comparison of Rolls Powered Earlier 747 and Current Production 747-400 Airplane"

(d) D340U401 and D340U402 Fuel System Analysis Documents

(e) FAA Letter 98-140S-112, "Fuel System Operation with Hot Center Tank Fuel", April 6, 1998

"An exemption from FAR 25.961(a)(5), Amendment 59, is requested for JP-4 and Jet B fuels on the following basis:

- *Existing 747/RB211-524 certification data demonstrates satisfactory JP-4 performance with an 80°F fuel temperature limitation.*
- *Similarity between the 747 classic and 747-400 airplane and fuel systems demonstrates that the existing 747 classic certification data is applicable to the 747-400.*
- *The significant operational and economic implications of not having JP-4* fuel capability demonstrate that this exemption is in the public interest.*
- *The proposed temperature and additional limitations for JP-4* fuel usage demonstrate a level of safety equal to the requirements of FAR 25.961(a)(5).*

" It should be noted that JP-4 is a military designation for a Jet B type commercial grade fuel with additives. In the discussions presented, the limitations associated with JP-4 fuels are intended to apply to Jet B type commercial grade fuels as well.*

"747-200/RB211-524B, 747-400/RB211-524G Fuel System Certification Data

"Fuel system performance has been satisfactorily demonstrated on the 747-200 /RB211-524B and the 747-400/RB211-524G with JP-4 fuel. Certification test results are documented in the Reference (a) and (b) Reports. During the 747-200 /RB211-524B testing, a suction feed climb was performed with 59°F JP-4 fuel at takeoff. Thrust deterioration was observed at 34,500 feet and boost pumps were turned on at approximately 35,000 feet. During the 747-400/RB211-524G testing, a suction feed climb was performed with 39°F JP-4 fuel at takeoff. Thrust deterioration was observed at 36,600 feet and boost pumps were turned on at approximately 37,700 feet. The climb was continued to service ceiling where the test engine boost pumps were shut off to simulate an all AC power loss. The test engine was successfully restarted on battery power during the descent at 16,500 feet. These test results were used to establish the suction feed capability of the aircraft/engine combination, which was used to develop the takeoff fuel temperature versus altitude restriction for the 747-400/RB211-524G-T/H-T.

"747-400/-400F/RB211-524G-T/H-T Fuel System Design Similarity

"Differences between the 747-200/RB211-524B, 747-400/RB211-524G, and 747-400/-400F/RB211-524G-T/H-T configurations will not have a significant affect on hot weather fuel system operations. The differences in the engine fuel system are documented in the Rolls-Royce report which is included as Enclosure 2. Changes to the airplane fuel system are outlined in the Reference (c) Boeing document. The only difference identified in the aircraft fuel system that may have an affect on hot weather suction feed fuel system operation was a change to the tank vent system. The 747-200 fuel vent system performance, which the RB211-524B was flight tested on, is better at altitudes between 10,000 feet and 35,000 feet. This is due to more efficient Ram air pressure recovery on the 747-200, the ram scoop being located in an area of higher pressure coefficients. At altitudes below 10,000 feet and above 35,000 feet, the 747-200 and 747–400/-400F vent system offers similar performance. An analysis of the performance contained in the Reference (c) Boeing document, shows that the 747-200 vent system offers an equivalent pressure altitude of 34,000 feet at 60°F dispatch JP-4 or Jet B fuel temperature corresponds to a limiting altitude of 32,600 feet for the 747-400/-400F.

"Engine installation differences between the 747-200/RB211-524B, 747-400 /RB211-524G, and the 747-400/-400F/RB211-524G-T/H-T also will not affect fuel system operations. An analysis of the engine changes between the 747-200 /RB211-524B, 747-400/RB211-524G, and 747-400/-400F/RB211-524 G-T/H-T is contained in the Enclosure 2 Rolls-Royce report.

"The following discussion addresses the requirement of FAR 11.25 . . .:

"Public Interest

"Boeing believes it is in the public interest for airlines to have the continued ability to operate their airplanes with JP-4 and Jet B fuels. Although the availability of these fuels is decreasing, they are still used in certain parts of the world and are sometimes the only fuel available at military airfields designated as alternate destinations. The operational and economical impact of not being able to rely on these airfields as alternates is significant. The following information was provided to Boeing by 747-400 customers.

"From British Airways (in response to a query sent by Boeing Customer Services):

Q1. Does your assigned operator use JP4 or Jet B fuel in their 747-400 airplanes? If yes, please respond to the remaining questions.

A1. Yes.

Q2. If so, how often (on a daily, weekly, monthly, or annual basis) and under what conditions (diversion, scheduled route, charter, etc.) is the JP4 or Jet B fuel used?

A2. Use only if there is a diversion over the North Atlantic during the winter months.

Q3. What are the cost implications of not having JP-4 or Jet B fuel capability in the 747-400 fleet operations? Please try to quantify this response in terms of U.S. dollars per year.

A3. Data not available.

Q4. Would the inability to use JP-4 or Jet B fuel cause your assigned operator to change any of their planned airplane revenue routes?

A4. Yes.

Q5. Please provide any other pertinent information which would help us describe to the FAA possible hardships (adverse economic impact) resulting from your assigned operator's inability to use JP-4 or Jet B fuel for your assigned operator's 747-400.

A5. No Comment.

"From Boeing's perspective, the economic impact of attempting to comply with the FAR 25.961(a)(5) as written would be debilitating. Because of the physical properties of JP-4 and Jet B Fuels, the current 747-400/-400F/RB211-524G-T/ H-T configurations cannot demonstrate the capability of operating on suction feed with 110°F JP-4 fuel to maximum altitude. A major redesign to the airplane fuel feed system, fuel tanks and possibly the airplane electrical system (to place the fuel pumps on battery power) could be required to develop this capability. Each of these changes would involve a costly re-certification effort of the 747 fuel feed system, which has had over twenty years of proven service.

"Equal Safety

"Boeing believes that incorporating a maximum fuel temperature and altitude limitation for JP-4 and Jet B fuels provides a level of safety equal to the provisions of FAR 25.961(a)(5). We believe the intent of FAR 25.961(a)(5) is to ensure that an airplane will be capable of operating in most parts of the world without being limited by fuel temperature. Limiting operations with a maximum fuel temperature will not affect public safety since the airplane has demonstrated the ability to operate in the proposed temperature range. The temperature limitation will only affect operators by preventing them from taking off under certain hot weather conditions (i.e. when the fuel tank temperature is greater than 80°F). To re-enforce an equal level of safety however, Boeing proposes to incorporate additional limitations for JP-4 and Jet B usage. The following package is being proposed for the 747-400/-400F/RB211-524G-T/H-T Flight Manuals:

"Operational Limits

"The maximum allowable fuel temperature at take-off for JP-4 or Jet B fuel is 80°F.

"The maximum allowable altitude when operating with JP-4 or Jet-B fuels is 36,000 feet.

"When operating with JP-4 or Jet B fuels, the maximum allowable altitude for the first 2 1/2 hours of cruise operation shall be limited to:

Dispatch Fuel Temperature (°F)	***Altitude Limit (Feet)***
60-80	*30,000*
40-60	*32,600*
40 or lower	*36,000*

"The fuel tanks must be de-fueled to sump level (i.e. the level at which fuel pump low-pressure lights illuminate) following operations with JP-4 or Jet B fuel. If the fuel tanks are not de-fueled, the JP-4 fuel usage limitations shall continue to apply.

JP-4 or Jet B fuel is prohibited for use in the center fuel tank.

"The intent of these restrictions is to ensure an equal level of safety when using these fuels. An airplane's ability to operate with JP-4 and Jet B fuel is a function of the vapor pressure of the fuel. The vapor pressures of wide cut fuels, like JP-4 and Jet B, are considerably higher than narrow cut fuels (i.e. Jet A and Jet A-1). Vapor pressure will also increase with temperature. At higher temperatures, the fuel is more likely to vaporize during suction feed operations, which can result in an engine flameout. This concern is addressed by limiting JP-4 and Jet B fuel temperatures (and thus vapor pressure) to a level that has been successfully demonstrated in flight-testing.

"In addition to fuel temperature, altitude is a concern with higher fuel vapor pressures. At higher altitudes, ambient pressures are lower which increases the chance of fuel vaporization during suction feed operation. Limiting the maximum altitude based on JP-4 fuel temperature at dispatch ensures that the airplane will operate below any potential engine flame out altitude. Table 1 below shows suction feed flight test data for JP-4 fuel temperatures at take-off ranging between 40°F to 118°F. Using this test data, it can be established that by limiting the fuel temperature at take-off and the corresponding altitude to below the demonstrated suction feed flame-out altitude, the aircraft will not experience a suction feed engine failure. The altitude based upon temperature is only required for the first 2-1/2 hours of flight at cruise because the fuel temperature cools sufficiently below the temperature at takeoff during the first 180 minutes. An analysis of the predicted fuel tank temperatures for the 747-400 can be found in Enclosure 1. Boeing believes that the combination of a temperature and altitude limitation for JP-4 and Jet B fuel usage on the 747-400/-400F/RB211-524G-T/H-T aircraft is very conservative, but together the limitations re-enforce a level of safety equivalent to the intent of FAR 25.961(a)(5).

TABLE 1

RB211-524 Powered 747 Suction Feed Climb Flight Test Data

Airplane	*Fuel*	*Take-Off Fuel Temp*	*Flame-Out (F.O.) Altitude (Kft)*	*Relight Altitude (Kft)*
RD131	*JP-4*	*59°F*	*34.5(+)*	*N/A*
RT451	*JP-4*	*39°F*	*36.6*	*15.7*
RM147	*JP-4*	*118°F*	*30.5*	*7.3*

"(+) The altitude limit using 60°F Jet-B/JP-4 fuel at take-off recorded during testing on the 747-200 was adjusted to 32,600 feet for the operational altitude limit on the 747-400 due to aircraft fuel vent performance differences as explained in Enclosure 1.

"It is important to note as well that there is an inherent margin of safety associated with limiting JP-4 fuel usage based on the suction feed capability of the engines. Under normal operating conditions, the airplane fuel boost pumps will be functioning. There are two AC powered boost pumps in each of the main fuel tanks, and two AC powered boost pumps in the center wing fuel tank. The center tank boost pumps have sufficient performance to feed the engines with the main boost pumps deadheaded. Under pressure feed conditions, the airplane can operate normally with JP-4 fuel at a dispatch temperature of 110°F up to the maximum altitude. This capability was demonstrated by analysis and qualification testing as presented in the Reference (d) D340U401 and D340U402 747-400 Fuel System Analysis documents. Continuous single engine suction feed is prevented by a Level B caution message and procedure. For the airplane to have to rely on continuous suction fuel feed, an all AC power loss would have to occur. Due to

numerous redundancies in the airplane electrical system, the probability of an all AC power loss is extremely low. To date, there have been no instances of complete AC power loss due to an electrical system failure on a 747-400. The one loss of AC power event on a 747-400 was caused by loss of all engines when the airplane flew through a cloud of volcanic ash.

"In the Reference (e) letter, the FAA also requested Boeing to provide information that addresses the hot center tank fuel concerns. Data is currently being collected that addresses the Reference (e) FAA concerns. This information will be provided to the FAA for all Boeing airplane models at a later date. Until a collective position can be provided, Boeing proposes to incorporate an AFM operational limitation for the 747-400/-400F/RB211-524G-T/H-T that prohibits the use of JP-4 or Jet B fuel in the center tank. Following resolution of the issues/concerns raised in the Reference (e) letter, Boeing may request to remove this interim limitation.

"Summary

"Based on the information provided, Boeing requests the FAA to grant an exemption to FAR 25.961(a)(5), Amendment 59, to allow an 80°F maximum fuel temperature limitation for JP-4 and Jet-B fuels on the 747-400/-400F/RB211-524G-T/H-T."

The petitioner provided additional data in several enclosures to the petition. This data is not reproduced here, but it is contained in the public docket for this petition for exemption, Docket FAA-2000-8062.

Notice and public procedure has been provided as follows:

On October 20, 2000 (65 FR 63113), the FAA published a notice of the petition for exemption in the Federal Register and requested comments from the public. No comments were received in response to the notice.

The Federal Aviation Administration's analysis of the petition is as follows:

The regulation regarding fuel system performance with hot fuel is intended to ensure that an uninterrupted fuel supply is provided to the engines. Section 25.961(a)(5) specifically requires that this capability be demonstrated with fuel at a temperature of at least 110 °F. Suction feed flight tests with JP-4 fuel temperatures at takeoff ranging between 39°F and 118°F were conducted on Boeing Models 747-200/RB211-524B and 747-400/RB211-524G airplanes during certification testing. Using this data, the petitioner established that, by limiting the fuel temperature at takeoff and the corresponding altitude to below the demonstrated suction feed flame-out altitude, the aircraft will not experience a suction feed engine failure. In this exemption, the petitioner has proposed operational limitations on dispatch fuel temperatures and altitude that ensure satisfactory fuel system performance will be achieved. These limitations are consistent with flight test performance previously demonstrated on the aircraft and engines.

The petitioner has requested that the Model 747-400/-400F/RB-211-524G-T/H-T airplanes be granted an exemption to § 25.961(a)(5). The information provided by the petitioner indicates that granting of the exemption to allow use of JP-4 and Jet B fuel would be in the public interest because it will allow the use of alternative airports for planning flights where

these fuels may be the only fuel available. Public safety would not be adversely affected because the temperature and fuel loading limitations placed on the airplane will limit operation of the airplane to fuel temperatures where satisfactory fuel system performance has been demonstrated.

The Grant of Exemption

In consideration of the foregoing, I find that a grant of exemption is in the public interest and will not adversely affect he level of safety provided by the regulations. Therefore, pursuant to the authority contained in 49 U.S.C. §§ 40113 and 44701, delegated to me by the Administrator, The Boeing Company is hereby granted an exemption from the fuel system hot weather operation requirements of § 25.961(a)(5), for the fuel system of the Boeing Model 747-400/-400F/RB-211-524G-T/H-T airplanes, with the operational limitations incorporated into the Airplane Flight Manual as proposed by the petitioner in the previous discussion.

Issued in Renton, Washington, on April 12, 2001.

Original signed by:

Ali Bahrami, Acting Manager
Transport Airplane Directorate
Aircraft Certification Service